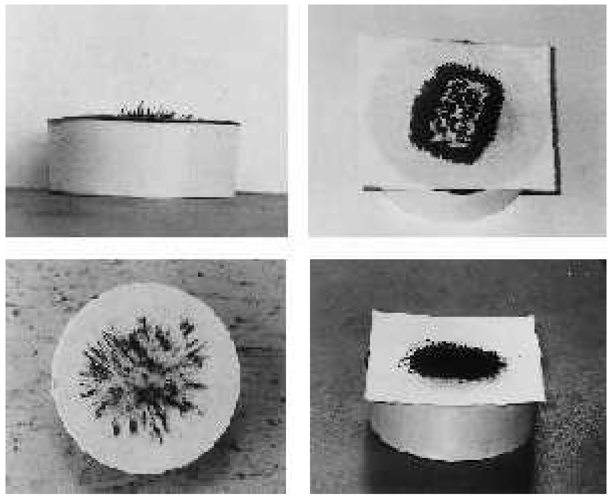
Iron-Containing Carbon Materials Fabricated



Iron-containing carbon materials on magnets.

Development of high-strength, lightweight materials for electromagnetic interference (EMI) shielding at low frequencies may be possible if the carbon fibers used in these composites can be made to have ferromagnetic properties. One way to obtain such fibers is by inserting small ferromagnetic particles into the fiber structure.

Carbon fibers and carbon powder containing iron oxide, iron metal, or iron alloy have been successfully fabricated at the NASA Lewis Research Center (refs. 1 and 2). These carbon products can be attracted to a regular magnet. Typical samples were estimated to have 1 iron atom per 3.5 to 5 carbon atoms. The sizes of the Fe_3O_4, iron metal, and iron alloy particles were estimated to be in a wide 10- to 10,000-angstrom range.

In this fabrication process, first graphite fluoride (CF_x) is exposed to $FeCl_3$. Then the product is further heated in a low-oxygen environment, thereby depositing iron oxide, elemental iron, or iron alloy in or on the carbon.

Experiments were conducted to study the kinetics of the fabrication process (ref. 2). At 280 to 295 °C, $FeCl_3$ can quickly enter the structure of CF_x; and in 10 to 30 min, it completely con verts the CF_x into carbon that has graphite planes between which crystalline FeF_3 and non crystalline $FeCl_2$ locate. Further heating this product in a low-oxygen environment converts these iron halides into either a mixture of FeO and Fe_3O_4, if the temperature is in 750 to 850 °C range, or into elemental iron, if the temperature is at least 900 °C. During the final heat treatment at a temperature of 900 °C or higher, NiO or $NiCl_2$ could be added to the reaction to produce a carbon material containing nickel-iron alloy, a ferromagnetic material.

In this reaction, a low rate of oxygen supply would cause the iron halide to evaporate before it could be converted to iron oxide, resulting in low iron concentration in the carbon products. On the other hand, a high rate of oxygen supply would cause carbon removal because of the formation of CO and CO2. The carbon removal would result in a high iron concentration in structurally damaged carbon products. At an optimum oxygen level, the iron halide in the carbon fibers would be converted to iron oxide or elemental iron without much halide evaporation or carbon structural damage. Potential applications of the iron-containing carbon fibers and powder include spacecraft and aircraft electronic packaging as well as portable, personal-use communication equipment.

References

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2. Hung, C.C.: Fabrication of Iron-Containing Carbon Materials From Graphite Fluoride. Presented at the 22nd Biennial Conference on Carbon, University of California, San Diego, July 1995. American Carbon Society, pp. 656-657, 1995